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FLOOD INSURANCE STUDY

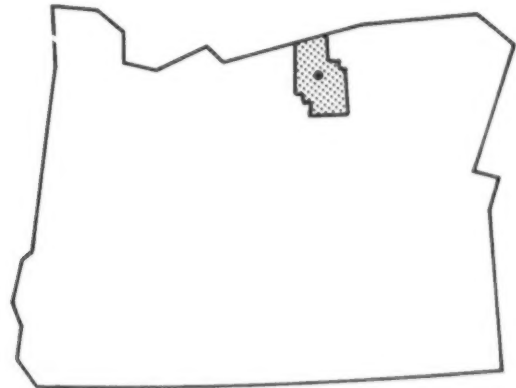


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CITY OF HEPPNER,
OREGON
MORROW COUNTY



OCTOBER 1, 1980



federal emergency management agency
federal insurance administration

COMMUNITY NUMBER - 410175

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PUBLISHED SEPARATELY:

Flood Insurance Rate Map

FLOOD INSURANCE STUDY

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of this Flood Insurance Study is to investigate the existence and severity of flood hazards in the City of Heppner, Morrow County, Oregon, and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Initial use of this information will be to convert Heppner to the regular program of flood insurance by the Federal Insurance Administration. Further use of the information will be made by local and regional planners in their efforts to promote sound land use and flood plain development.

1.2 Coordination

Streams requiring detailed study were identified at a meeting held in July 1977 that was attended by representatives of the study contractor, the Federal Insurance Administration, and the City of Heppner.

The results of this study were reviewed at a final community coordination meeting held on May 1, 1980. Attending the meeting were representatives of the Federal Insurance Administration, the study contractor, and the city. No problems were raised at the meeting.

1.3 Authority and Acknowledgments

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968, as amended.

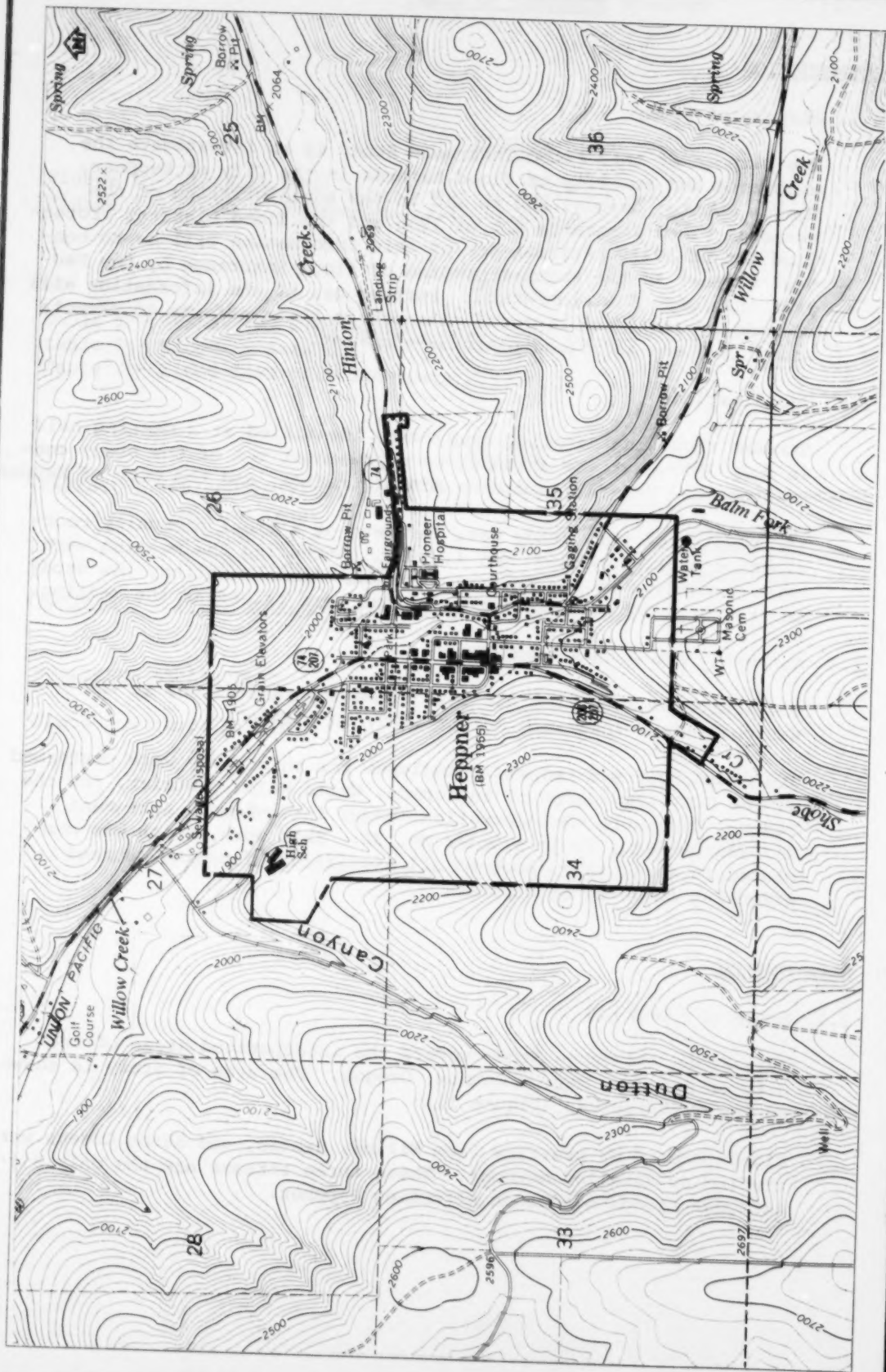
The hydrologic and hydraulic analyses for this study were performed by the U.S. Army Corps of Engineers, Walla Walla District, for the Federal Insurance Administration, under Inter-Agency Agreement No. IAA-H-10-77, Project Order No. 32. This work, which was completed in April 1979, covered all significant flooding sources affecting the City of Heppner.

2.0 AREA STUDIED

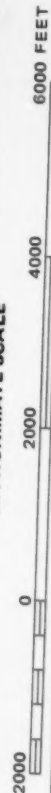
2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Heppner, Morrow County, Oregon. The area of study is shown on the Vicinity Map (Figure 1).

Floods caused by overflow from Willow, Hinton, and Shobe Creeks were studied by detailed methods. These three streams are the only significant flooding sources affecting Heppner.



APPROXIMATE SCALE



VICINITY MAP

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Federal Insurance Administration

CITY OF HEPNER, OR
(MORROW CO.)

FIGURE 1

Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development through 1984.

2.2 Community Description

Heppner is in central Morrow County in north-central Oregon. It is along Willow Creek, approximately 40 miles south of Boardman and Interstate Highway 80. The community is surrounded by unincorporated areas of Morrow County.

The city was incorporated in 1887 and has been the county seat since 1885. The population of Heppner in 1970 was 1429 (Reference 1).

Heppner is in a narrow valley where Hinton Creek, Shobe Creek, and Balm Fork flow into Willow Creek. The Willow Creek basin is approximately 60 miles long and has a maximum width of 23 miles. The city is surrounded by rolling hills, and elevations range from 2300 to over 5900 feet.

The flood plains in Heppner are highly developed for both commercial and residential uses.

The climate of the area is semiarid. The average annual precipitation is approximately 12 inches. Summers are dry, and much of the annual precipitation occurs during the winter and spring. The average annual temperature is 50°F. Extreme temperatures have reached above 100°F in the summer and below 0°F in the winter.

Soils in the area are sandy loams and support vegetation consisting of sagebrush and greasewood.

2.3 Principal Flood Problems

There are three types of floods common to the Willow Creek basin. A period of annual high water, caused by melting snow, sometimes augmented by rainstorms, occurs in early spring. These flows, however, seldom exceed channel capacities. Another type of flood is the winter-rain snowmelt flood, which usually occurs from December through February. These floods are the result of above-average snowfall, followed by warm rain, on frozen ground. However, the most damaging floods in the basin are caused by violent summer thunderstorms with intense rainfall. Floods of significant size occurred in 1885, 1888, 1891, 1903, 1904, 1917, 1918, 1961, and 1971. In May 1971, a thunderstorm at Heppner caused a flash flood in Shobe Creek, and the estimated peak discharge was 6000 cubic feet per second (cfs). The most destructive flood, however, occurred in June 1903. The storm was centered in the headwater areas of Balm Fork and Willow Creek above Heppner. The flood was

estimated to have had a peak discharge of 36,000 cfs above Balm Fork and to have had an estimated recurrence interval of 360 years at the confluence of Balm Fork and Willow Creek. The flood caused the loss of 247 lives.

The destructive effect of these cloudburst floods is due, in part, to the rugged character of the watershed, the almost total lack of vegetation, and the sudden onset of thunderstorms.

2.4 Flood Protection Measures

There are no flood protection structures on the streams studied within the corporate limits of Heppner.

The National Weather Service provides flash-flood forecasts and warnings under its Flash Flood Alert, Watch and Warning Program. The City of Heppner and Morrow County, in cooperation with the National Weather Service and the Defense Civil Preparedness Agency, have established a Flash Flood Alarm System and Warning Plan. The inhabitants of Heppner and the industries along the streams are warned by a siren of approaching flood conditions and are advised to evacuate the area.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual occurrence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each stream studied in detail in the community.

The annual peak discharge-frequency curves for Willow Creek through Heppner were developed by the study contractor (Reference 2) by using a combination of historic floods, synthetic storms developed by using U.S. Weather Bureau data (Reference 3), and records from a gaging station on Willow Creek at the Court Street bridge in Heppner. This gage has been operated since May 1951. The synthetic storms were developed from U.S. Weather Bureau data and were then applied to the basins by using appropriate loss rates and standard hydrological routing methods. The historic flood record was based on past flood reports, newspaper accounts, and interviews with people in the area.

Hinton Creek and Shobe Creek have no streamflow records and, therefore, the historic floods and synthetic storms were the principal means of calculating the frequency curves.

Peak discharge-drainage area relationships for Willow Creek, Hinton Creek, and Shobe Creek are shown in Table 1.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of streams in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each stream studied in the community.

Elevations of floods of the selected recurrence intervals were computed through the use of the U.S. Army Corps of Engineers HEC-2 step-backwater computer program (Reference 4).

Cross sections for the streams in the area were obtained by field surveys. All bridges and culverts were surveyed in order to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

Roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations of the streams and flood plain areas. Roughness values for the main channels range from 0.040 to 0.045, and the flood plain roughness value is 0.045 for all floods.

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second)		
		10-Year	50-Year	100-Year
Willow Creek Above Confluence With Shobe Creek Above Confluence	96.0	1,590	11,400	23,800
With Hinton Creek Below Confluence	102.8	1,960	12,000	25,000
With Hinton Creek	146.8	3,620	20,500	37,600
Hinton Creek At Mouth	44.0	2,330	11,500	15,460
Shobe Creek At Mouth	6.8	455	2,530	3,630
				5,270

Starting water-surface elevations for all streams studied in the community were obtained from normal-depth calculations.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals (Exhibit 1).

When the computed water-surface elevation is near the critical-depth elevation, unstable flow conditions can be expected. For cross sections at which unstable flow is expected, the elevations presented on the Flood Profiles (Exhibit 1) are the computed elevations at critical depth plus 40 percent of the velocity head at critical depth. The resulting depth is equal to 1.1 times critical depth for triangular channels and, therefore, is a conservatively high approximation for other channel shapes (Reference 5).

The hydraulic analyses for this study were based on unobstructed flow. Therefore, flood elevations shown on the profiles are considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in the study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage State and local governments to adopt sound flood plain management programs. Each Flood Insurance Study, therefore, includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Insurance Administration as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were developed photogrammetrically, using aerial photographs at a scale of 1:4800 (Reference 6).

Flood boundaries presented in this study are based on the computed water-surface elevations.

Flood boundaries for the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year flood boundary has been shown. Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to limitations of the map scale, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity and increases flood heights, thus increasing flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment in order that the 100-year flood be carried without substantial increases in flood heights. As minimum standards, the Federal Insurance Administration limits such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced.

In high-velocity channels when flow is near critical depth, a relatively small change in specific energy can create a substantial change in water surface and make it impossible to obtain a 1-foot rise at each section from encroachment. Therefore, encroachments were generally set to produce a 1-foot increase in specific energy, which reflects the maximum potential water-surface elevation.

The floodways presented in this study were computed on the basis of equal-conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 2).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood boundaries are close together, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the specific energy of the 100-year flood more

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY	INCREASE ²
Willow Creek								
A	565	676/540 ³	3417	11.0	1897.9	1897.9	1898.9	1.0
B	1035	713	4281	8.8	1901.7	1901.7	1902.7	1.0
C	1420	567	3105	12.1	1906.6	1906.6	1907.0	1.0
D	1755	546	3556	10.6	1909.9	1909.9	1910.2	1.0
E	2130	462	2851	13.2	1913.8	1913.8	1914.7	1.0
F	2540	612	4178	9.0	1917.4	1917.4	1918.7	1.0
G	2785	593	4159	9.0	1919.5	1919.5	1919.9	1.0
H	3365	610	3223	11.7	1924.6	1924.6	1925.4	1.0
I	3710	691	4471	5.6	1930.5	1930.5	1930.5	0.0
J	4050	522	2430	10.3	1931.2	1931.2	1931.9	1.0
K	4480	471	2311	10.8	1936.2	1936.2	1936.2	1.0
L	4925	815	3782	6.6	1939.2	1939.2	1940.2	1.0
M	5310	792	3748	6.7	1942.0	1942.0	1942.1	0.0
N	5770	458	2211	11.3	1947.1	1947.1	1947.1	0.0
O	6230	452	2168	11.5	1955.2	1955.2	1955.6	0.7
P	6720	307	1945	12.9	1961.1	1961.1	1961.5	1.0
Q	7085	300	2673	8.9	1963.2	1963.2	1964.3	1.0
R	7345	263	1834	13.0	1967.1	1967.1	1967.6	1.0
S	7645	273	1806	13.2	1971.8	1971.8	1972.2	1.0
T	8000	241	2164	11.0	1972.9	1972.9	1974.3	1.0
U	8400	203	1658	14.4	1979.9	1979.9	1980.3	1.0
V	8765	300	3814	6.2	1989.8	1989.8	1989.8	0.1
W	9115	300/260 ³	2143	11.1	1989.8	1989.8	1989.8	0.3

¹ Feet Above Limit of Flooding Affecting City of Heppner
Within Corporate Limits

² In Specific Energy

³ Width/Width

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FLOODWAY DATA

WILLOW CREEK

TABLE 2

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY	INCREASE ²
Hinton Creek A B C D E F	250	230	1317	11.7	1931.6	1931.6	1932.0	0.4
	485	201	1318	11.7	1934.0	1934.0	1934.0	1.0
	600	178	1187	13.0	1939.1	1939.1	1939.5	1.0
	980	201	1393	11.1	1946.5	1946.5	1946.5	1.0
	1365	150	1159	13.3	1956.7	1956.7	1956.7	0.2
	1685	200	1416	10.9	1961.4	1961.4	1961.4	0.1
Shobe Creek A B C D E F	650	123	403	9.0	1979.2	1979.2	1979.3	0.5
	1000	76	413	8.8	1984.9	1984.9	1984.9	0.1
	1300	70	302	12.0	1994.8	1994.8	1994.8	0.0
	1815	58	295	12.3	2006.1	2006.1	2006.1	0.0
	2285	125	381	9.5	2038.5	2038.5	2038.6	0.5
	3085	72	308	11.8	2065.9	2065.9	2065.9	0.0

¹ Feet Above Mouth ² In Specific Energy

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CITY OF HEPNER, OR

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FLOODWAY DATA

HINTON CREEK SHOBE CREEK

than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

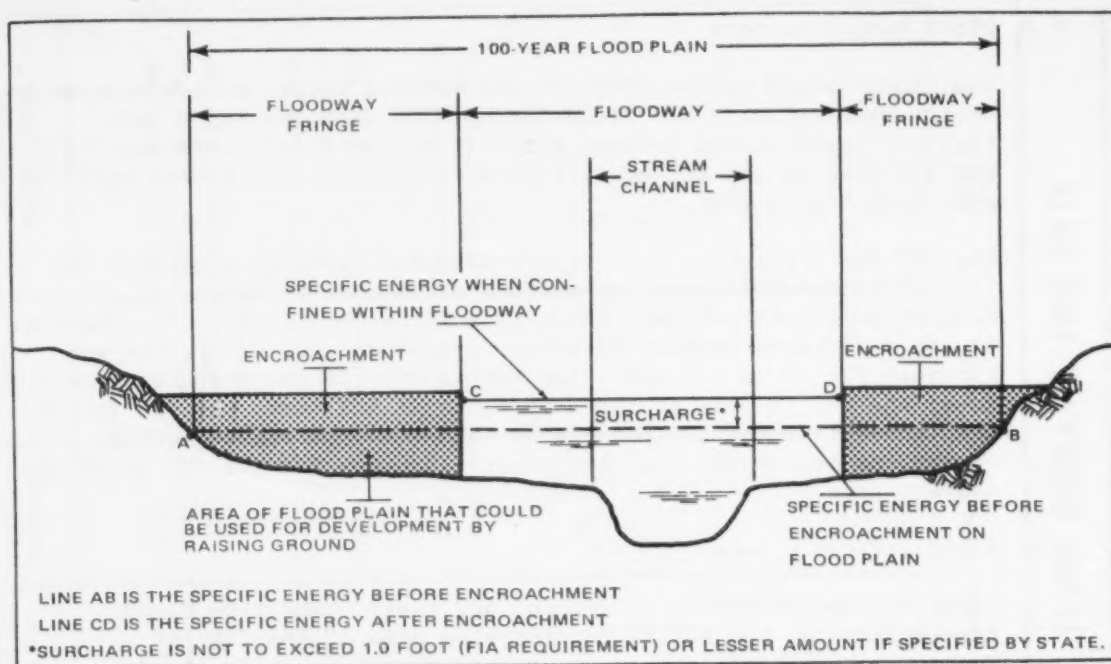


Figure 2. Floodway Schematic

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the Federal Insurance Administration has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the City of Heppner.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of Heppner are shown on the Flood Profiles (Exhibit 1) and summarized in Table 3.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the Federal Insurance Administration device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables based on FHF's from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest one-half foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective Flood Hazard Factors, the entire incorporated area of the City of Heppner was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zones A10, A11, A12, A15,
A19, and A20:

Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to Flood Hazard Factors.

Zone B:

Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C:

Areas of minimal flooding.

FLOODING SOURCE	PANEL ¹	ELEVATION DIFFERENCE ² BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION ³ (FEET NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Willow Creek Reach 1 Reach 2 Reach 3	0001 0001 0001	-4.8 -7.3 -9.9	-1.5 -2.1 -3.0	1.1 1.4 2.5	050 075 100	A10 A15 A20	Varies - See Map Varies - See Map Varies - See Map
Hinton Creek Reach 1 Reach 2 Reach 3	0001 0001 0001	-5.1 -6.1 -9.4	-1.3 -1.1 -1.8	1.0 1.0 1.6	050 060 095	A10 A12 A19	Varies - See Map Varies - See Map Varies - See Map
Shobe Creek Reach 1 Reach 2	0001 0001	-7.3 -5.5	-1.8 -1.3	1.3 1.5	075 055	A15 A11	Varies - See Map Varies - See Map

¹Flood Insurance Rate Map Panel ²Weighted Average ³Rounded to Nearest Foot

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FLOOD INSURANCE ZONE DATA

WILLOW CREEK-HINTON CREEK-SHOBE CREEK

TABLE 3

The flood elevation differences, Flood Hazard Factors, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community are summarized in Table 3.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Heppner is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the Federal Insurance Administration.

The base flood elevation lines shown on the Flood Insurance Rate Map for Heppner are based on the elevations as presented on the Flood Profiles (Exhibit 1).

6.0 OTHER STUDIES

A Flood Plain Information report was prepared for Hinton, Shobe, and Willow Creeks in the vicinity of Heppner (Reference 7). Due to the more indepth hydrologic analysis in this study, it supersedes the Flood Plain Information report.

Flood Insurance Studies are being prepared for the City of Ione (Reference 8), the City of Lexington (Reference 9), and the unincorporated areas of Morrow County (Reference 10). The same data and analyses were used for all Flood Insurance Studies in Morrow County, and, therefore, they are in complete agreement.

The Federal Insurance Administration has previously published a Flood Hazard Boundary Map for the City of Heppner (Reference 11). Due to the more detailed analyses used in this study, it supersedes the Flood Hazard Boundary Map.

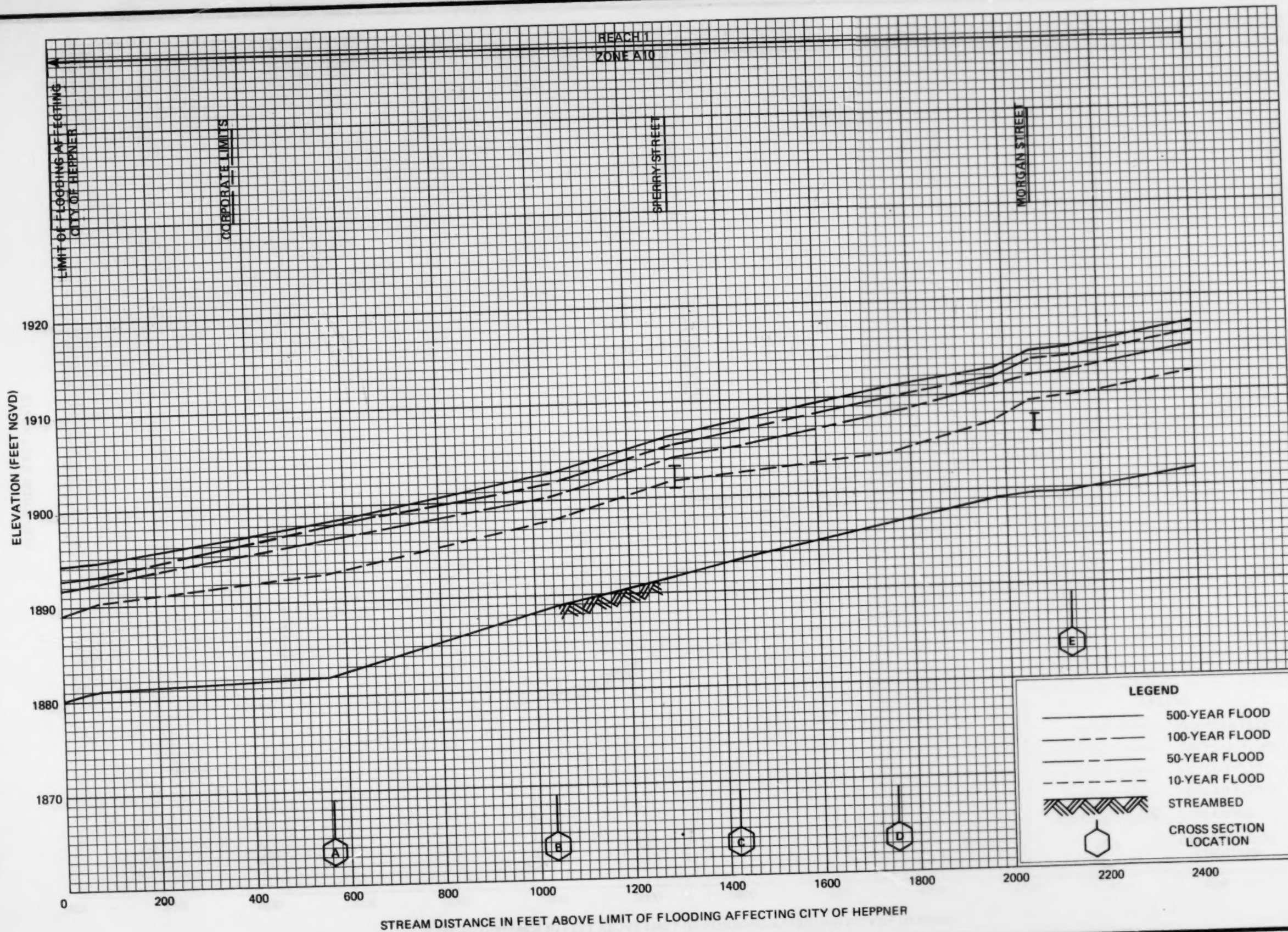
This study is authoritative for the purposes of the National Flood Insurance Program; data presented herein either supersede or are compatible with all previous determinations.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the Insurance and Mitigation Division, Federal Emergency Management Agency, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98011.

8.0 BIBLIOGRAPHY AND REFERENCES

1. East Central Oregon Association of Counties, Draft Technical Report, Heppner, Oregon, March 1978
 2. U.S. Department of the Army, Corps of Engineers, Hydrologic Report, Streams of Morrow County, Oregon, November 1978
 3. U.S. Department of Commerce, Weather Bureau, Technical Paper 49, Two-to-Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States, 1964
 4. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water-Surface Profiles, Generalized Computer Program, Davis, California, November 1976
 5. U.S. Department of the Army, Corps of Engineers, Engineering Manual 110-2-1601, July 1970
 6. U.S. Department of the Army, Corps of Engineers, Aerial Photographs, Scale 1:4800, City of Heppner, Oregon, March 1973
 7. U.S. Department of the Army, Corps of Engineers, Flood Plain Information, Hinton, Shobe, and Willow Creeks, Heppner, Oregon, June 1974
 8. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, City of Ione, Oregon, unpublished
 9. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, City of Lexington, Oregon, unpublished
 10. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, Morrow County, Oregon (Unincorporated Areas), unpublished
 11. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map, City of Heppner, Oregon, Scale 1:9600, Revised December 1975
- Chow, Ven Te, Open Channel Hydraulics, New York: McGraw-Hill, Inc., 1959
- U.S. Department of the Army, Corps of Engineers, Statistical Methods in Hydrology, Sacramento, California, January 1962
- U.S. Department of the Interior, Geological Survey, Water-Supply Paper 1849, Roughness Characteristics of Natural Channels, 1967



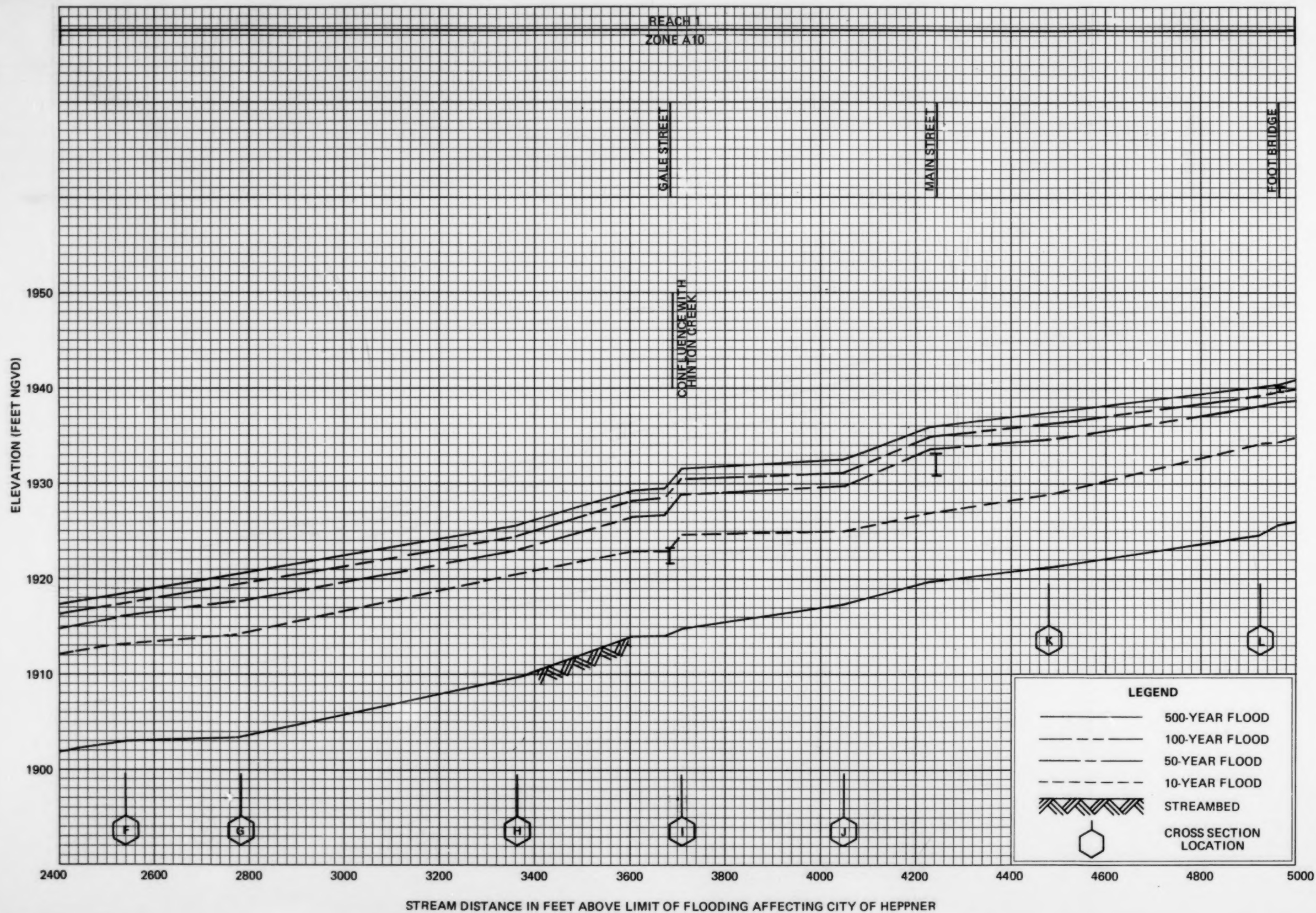
FLOOD PROFILES

WILLOW CREEK

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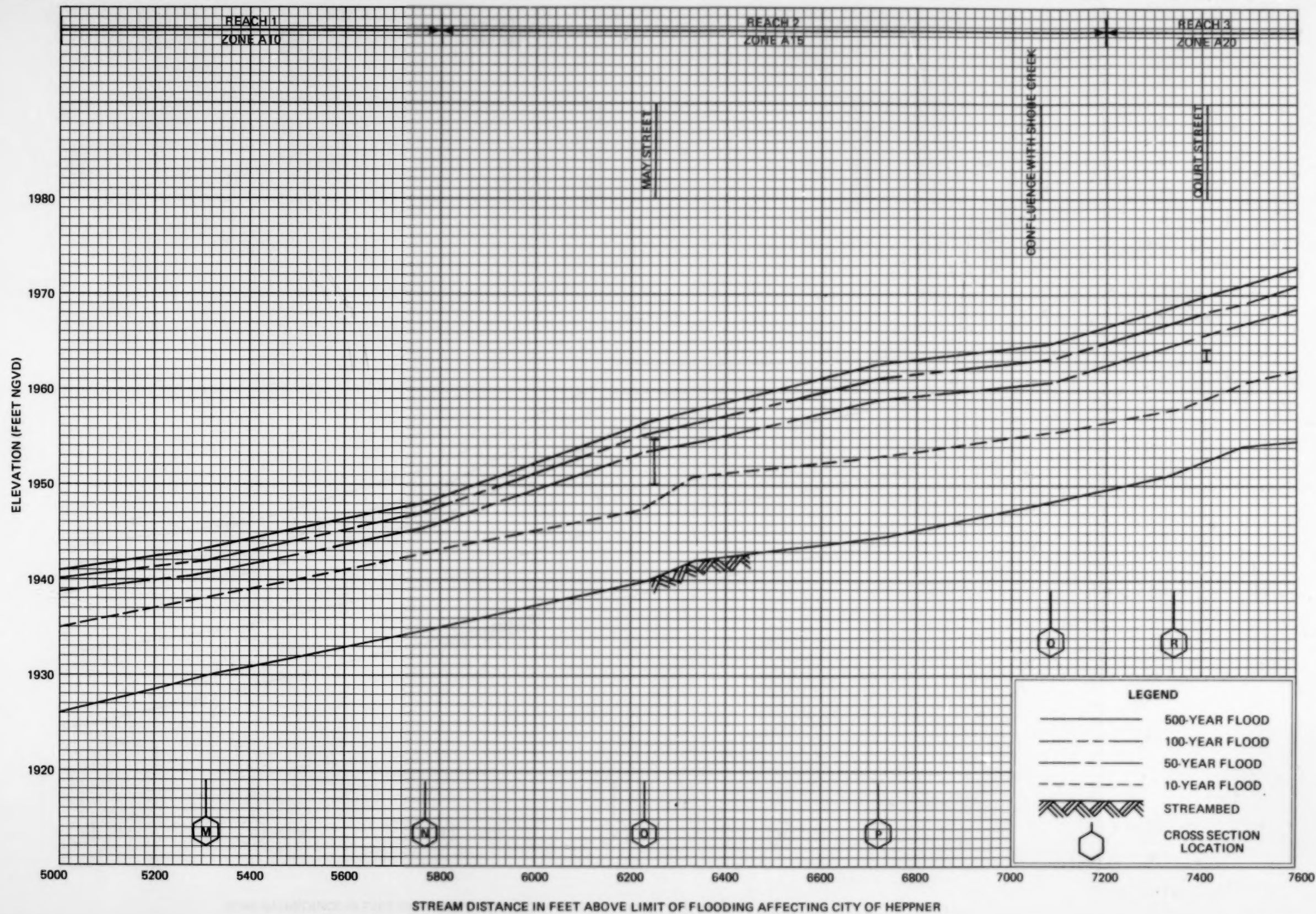
FLOOD PROFILES

WILLOW CREEK

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(MORROW CO.)

02P



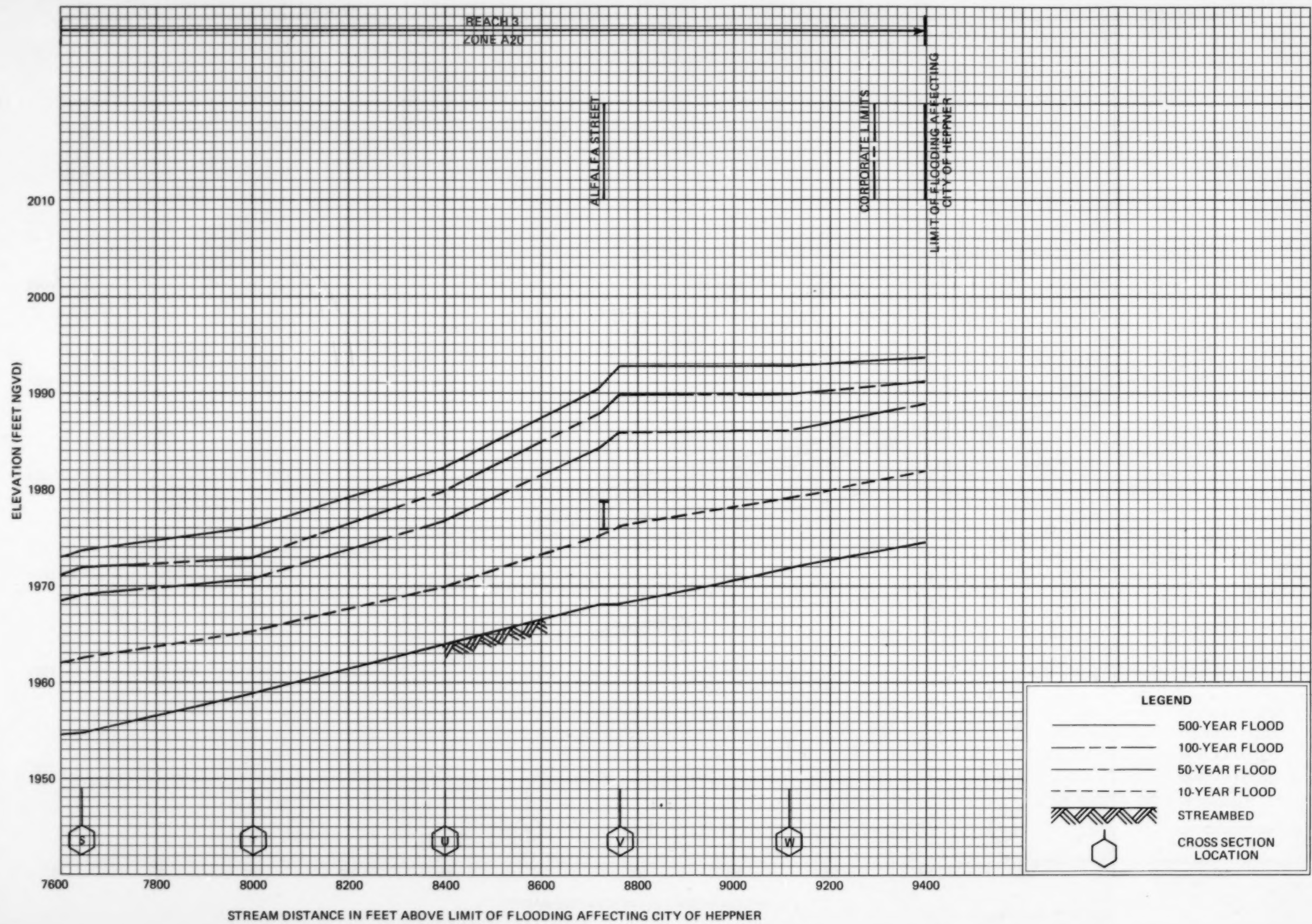
FLOOD PROFILES

WILLOW CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

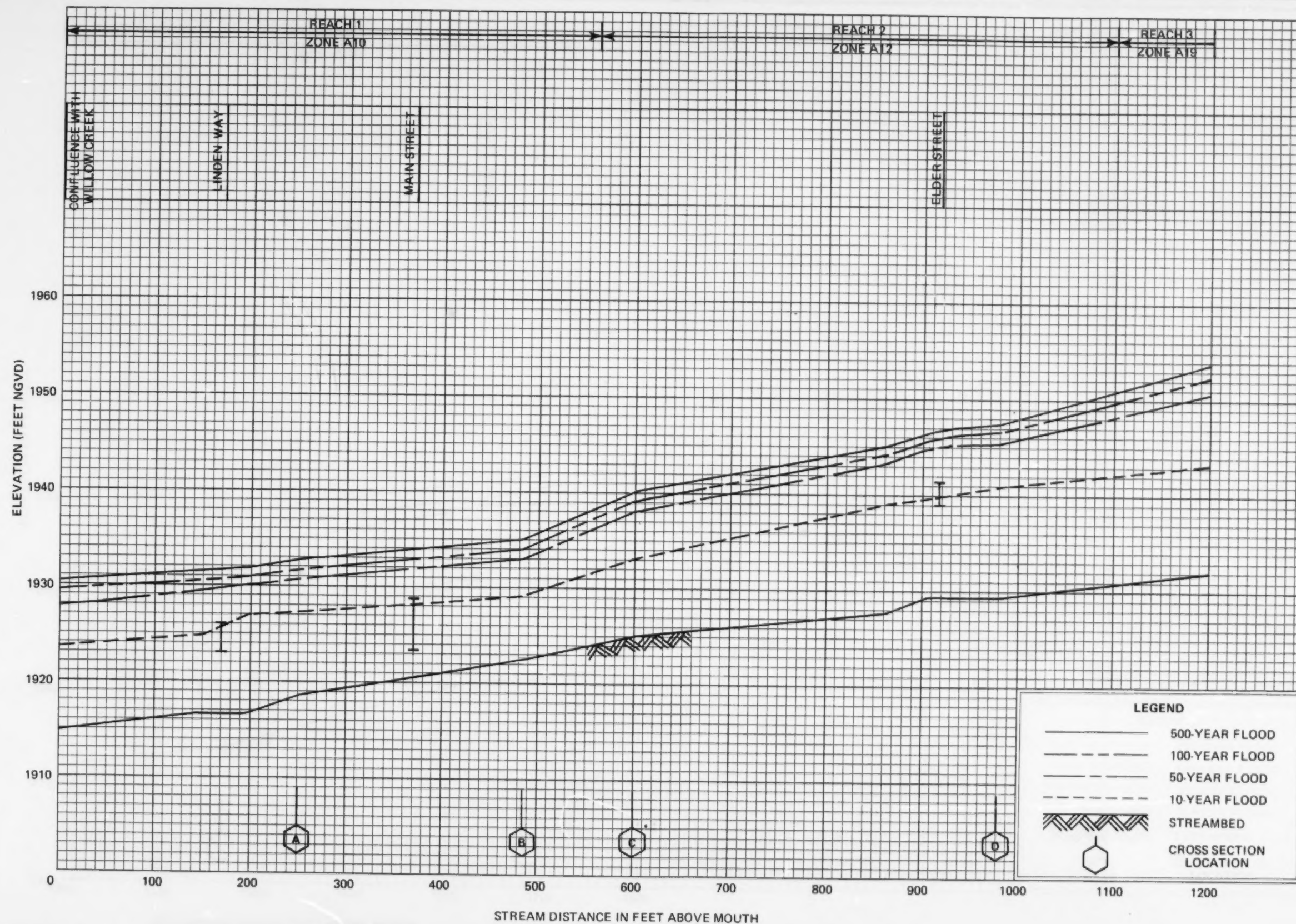
CITY OF HEPNER, OR
(MORROW CO.)

03P



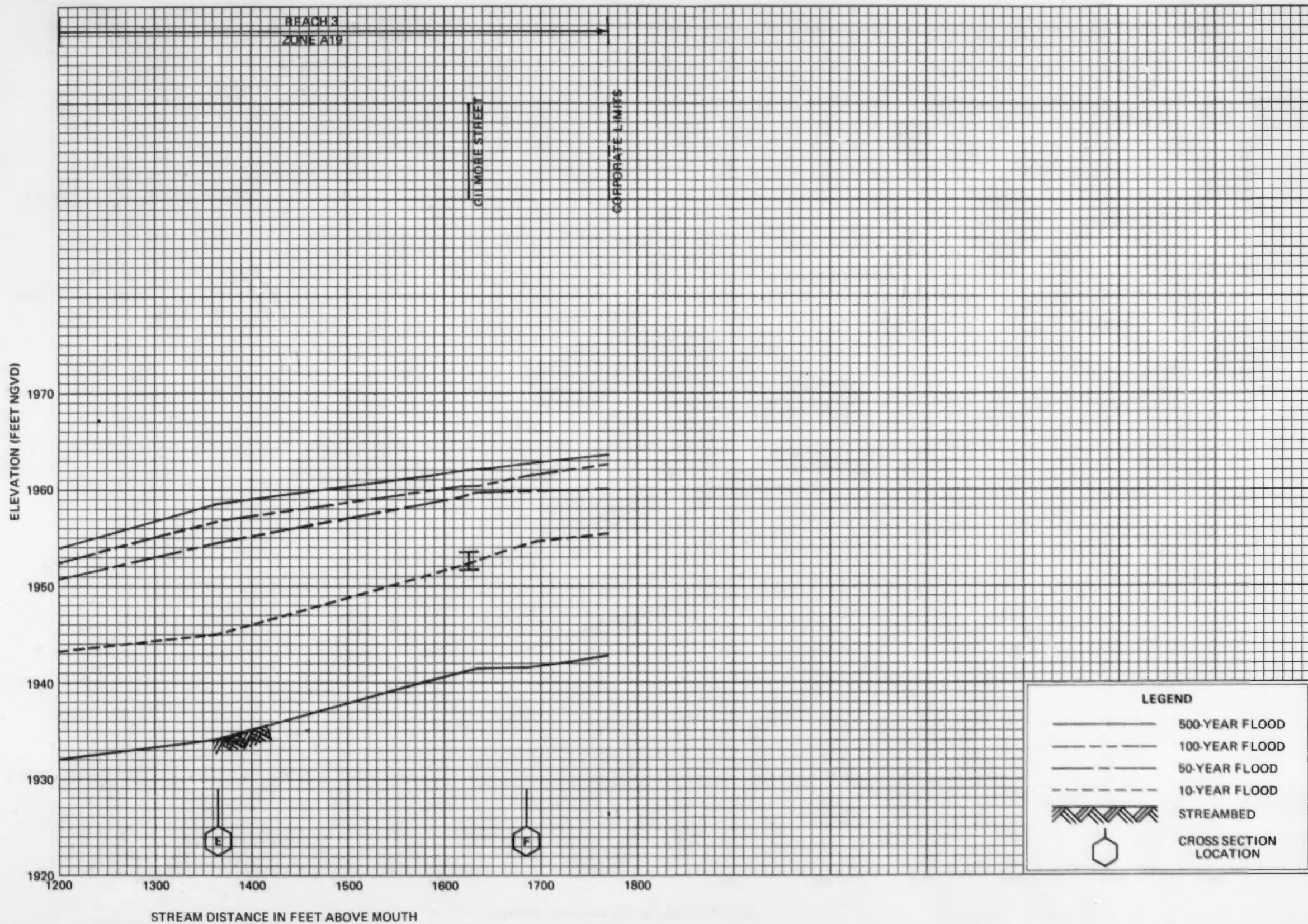
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(MORROW CO.)



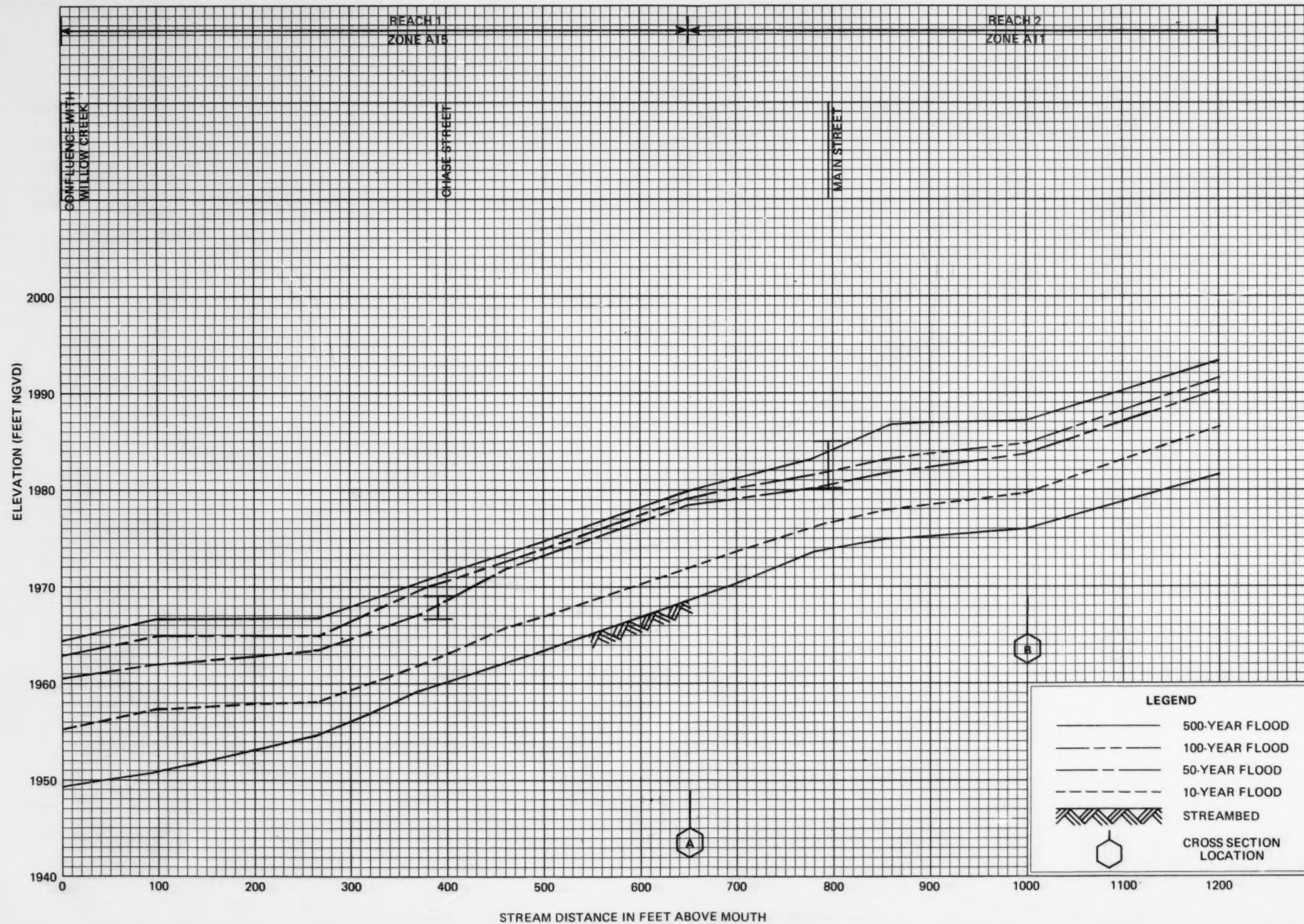
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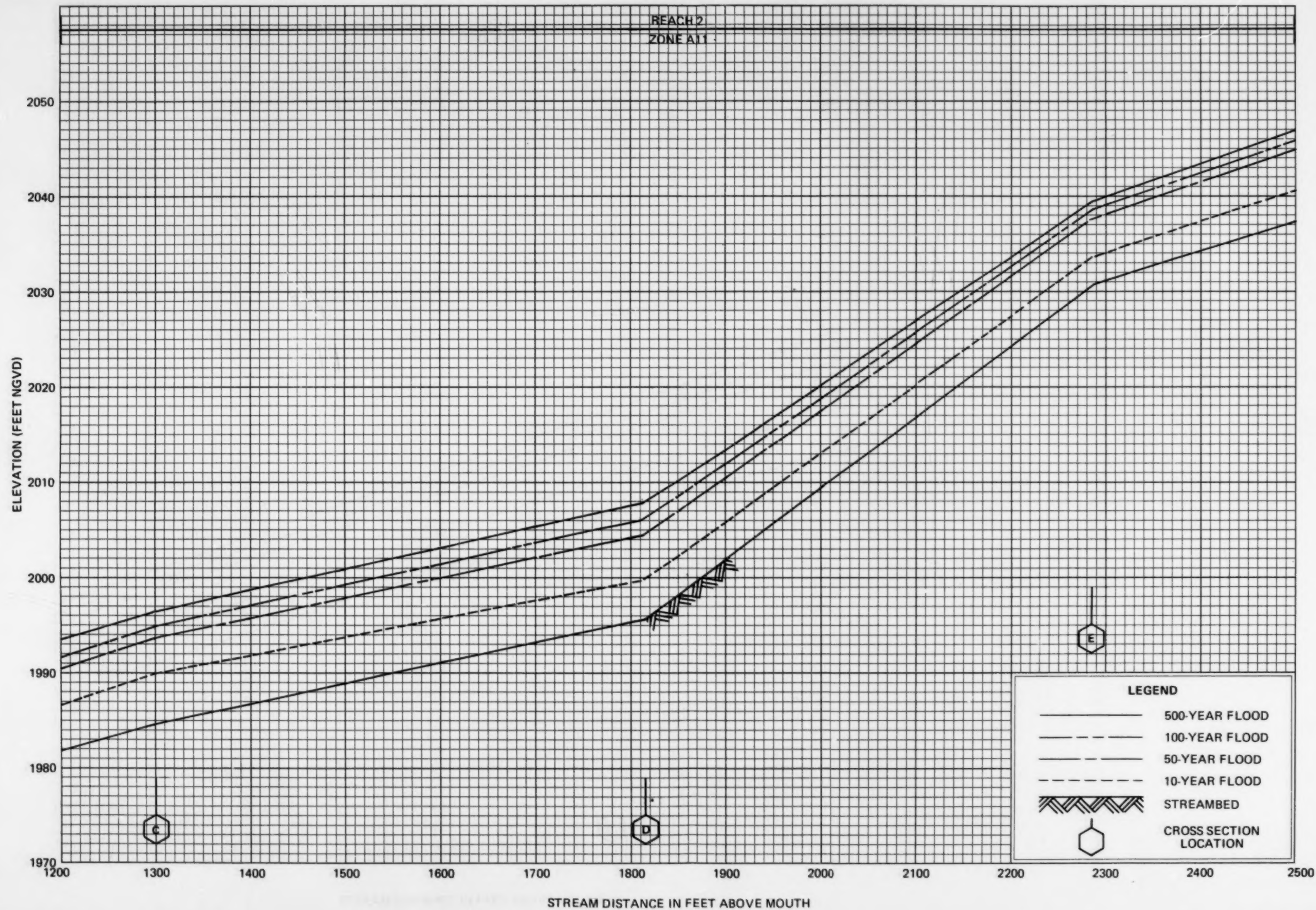
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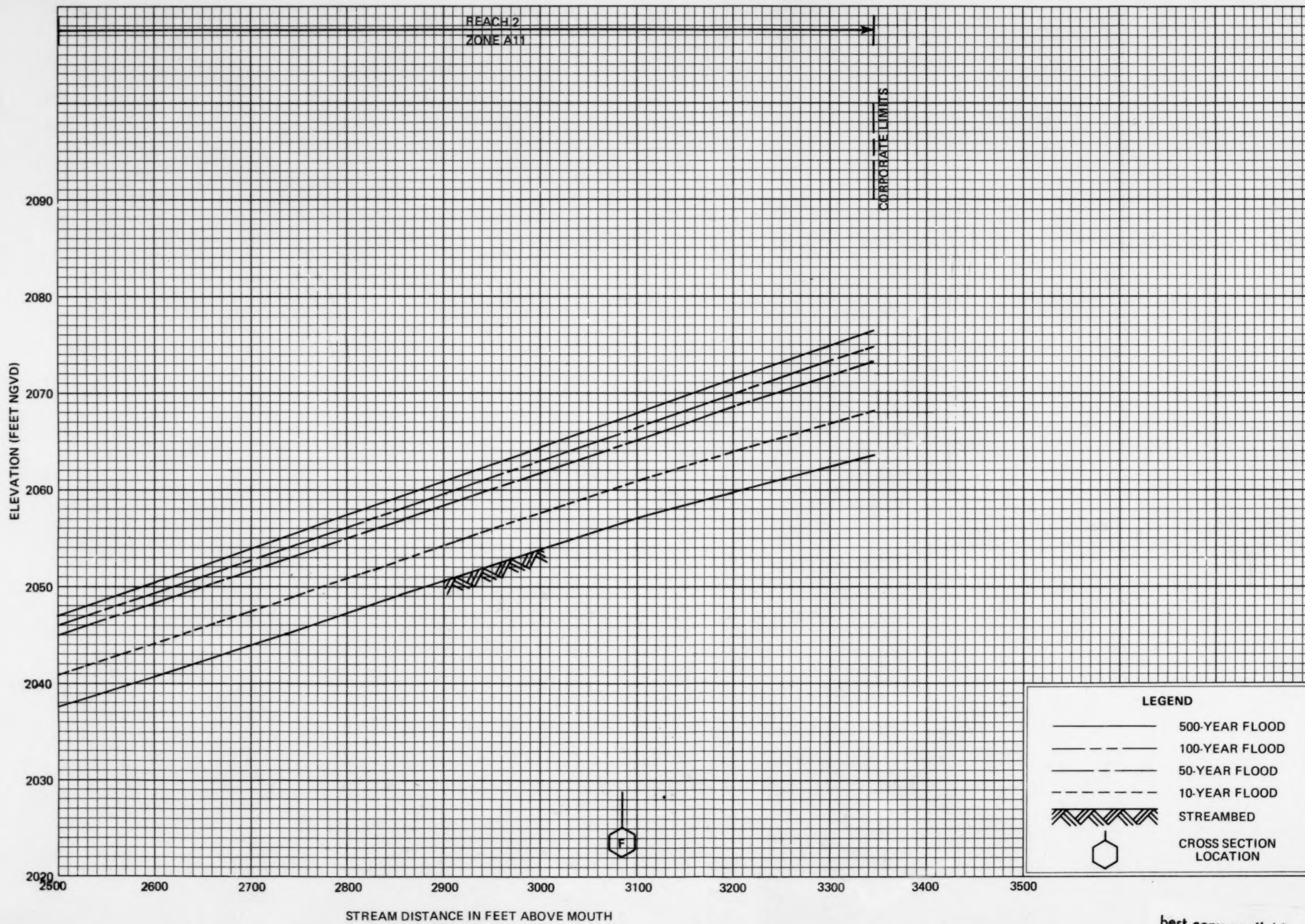
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